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(54) **MECHANISM FOR DIVIDING TISSUE IN A HEMOSTAT-STYLE INSTRUMENT**

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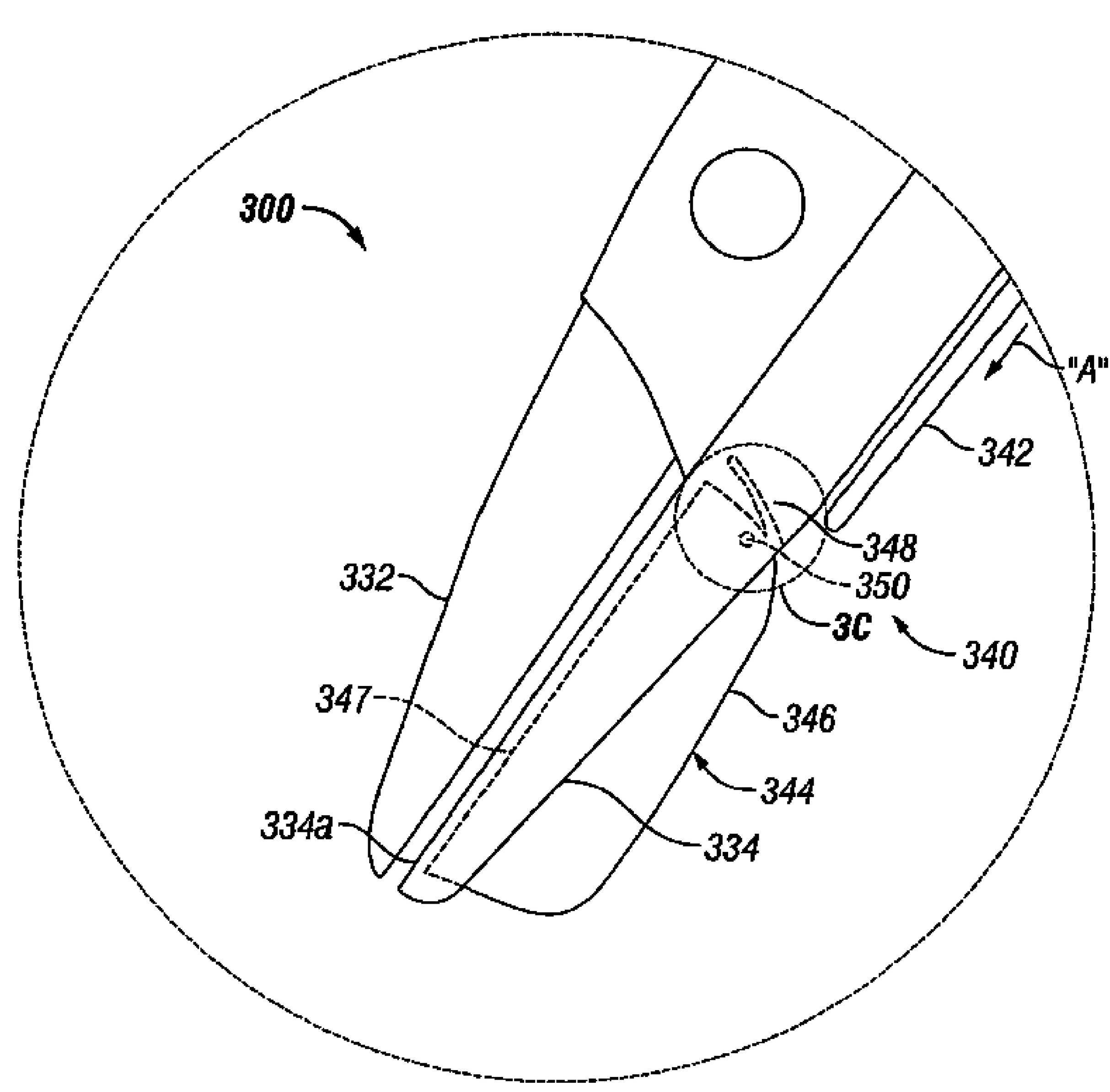
(57) **ABSTRACT**

Open electrosurgical forceps for sealing tissue are provided which include first and second shaft portions pivotably associated with one another. Each shaft portion has a jaw member disposed at a distal end thereof. Each of the jaw members includes an electrically conductive sealing surface adapted to communicate electrosurgical energy through tissue held therebetween and a slot formed through the sealing surface thereof. The forceps includes a cutting mechanism operatively associated with the first and second jaw members. The cutting mechanism includes a cutting element disposed within the slot of the at least one jaw member, the cutting element being movable from a first position wherein the cutting element is retracted within the at least one jaw member and a second position in which the cutting element at least partially projects from a sealing surface of the at least one jaw member.

13 Claims, 14 Drawing Sheets



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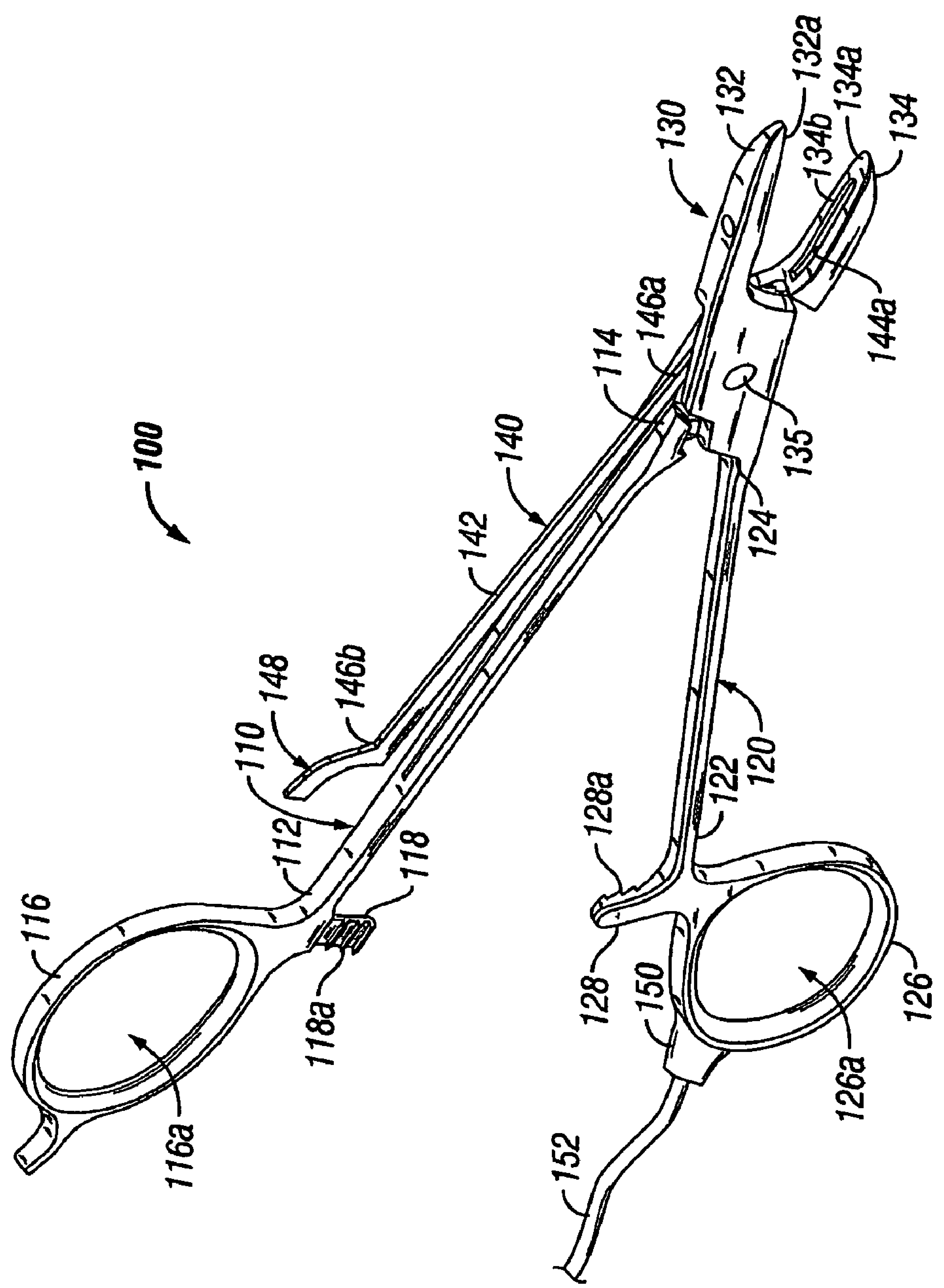
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FIG. 1A

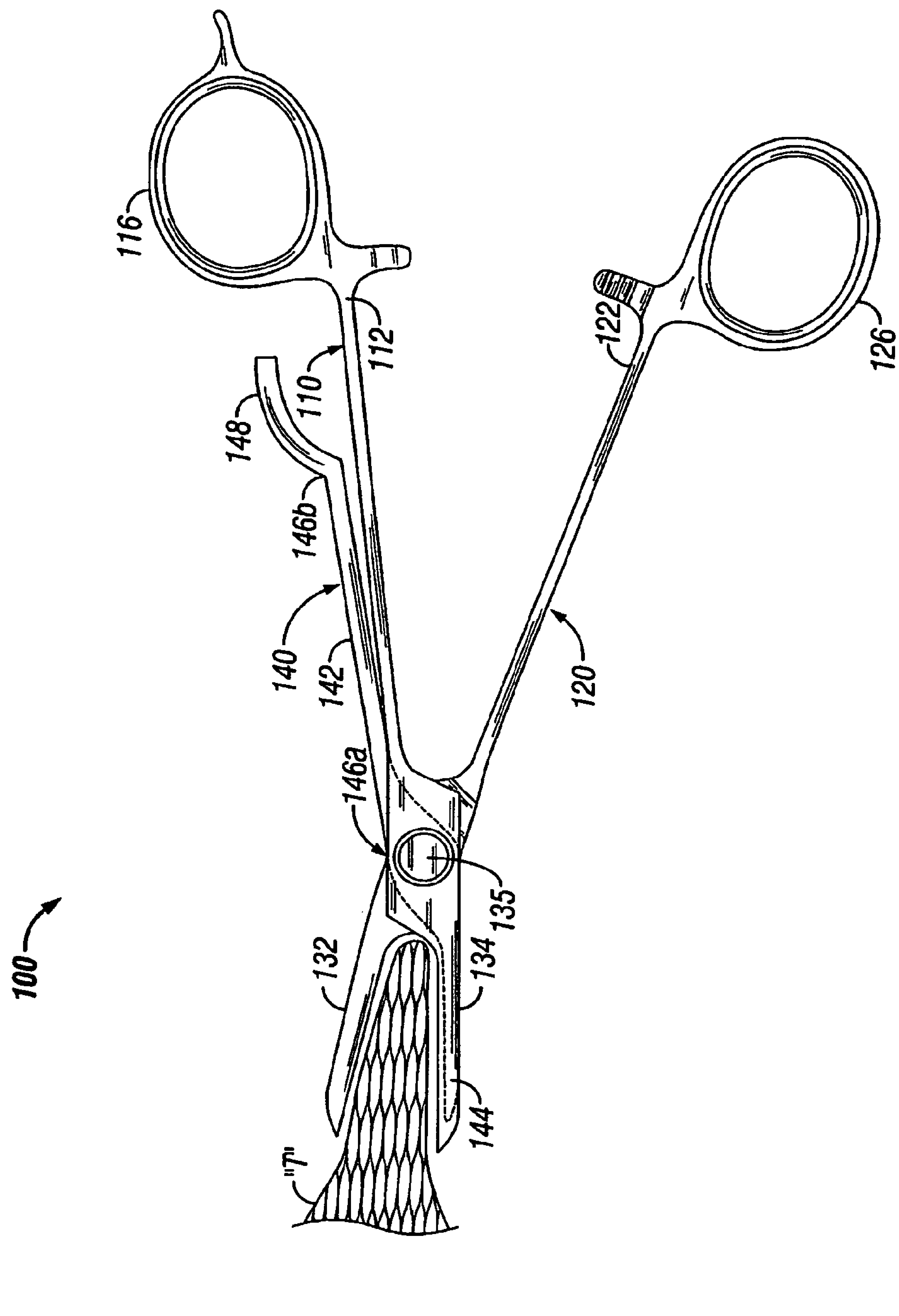
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FIG. 1B

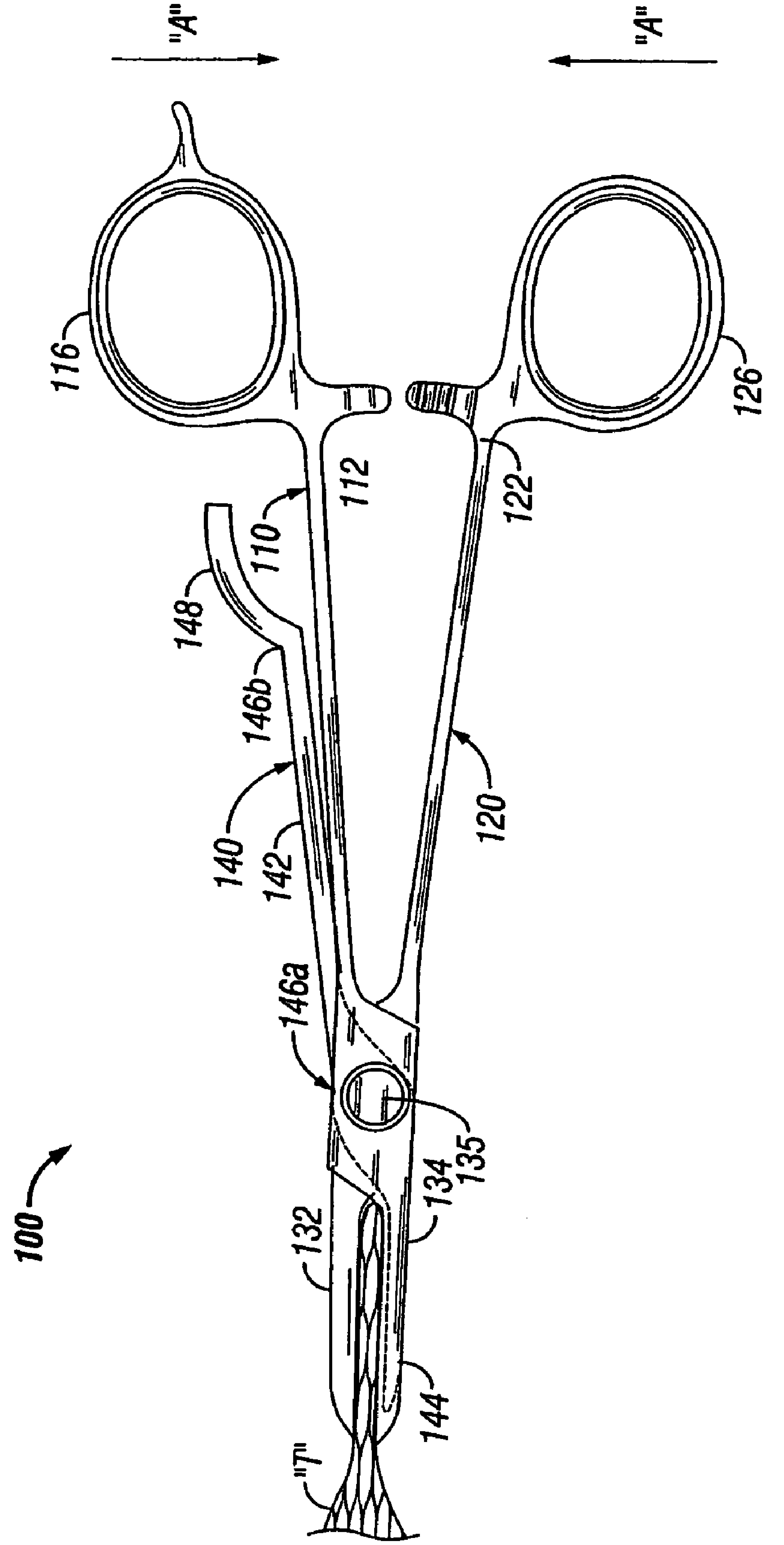
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FIG. 1C

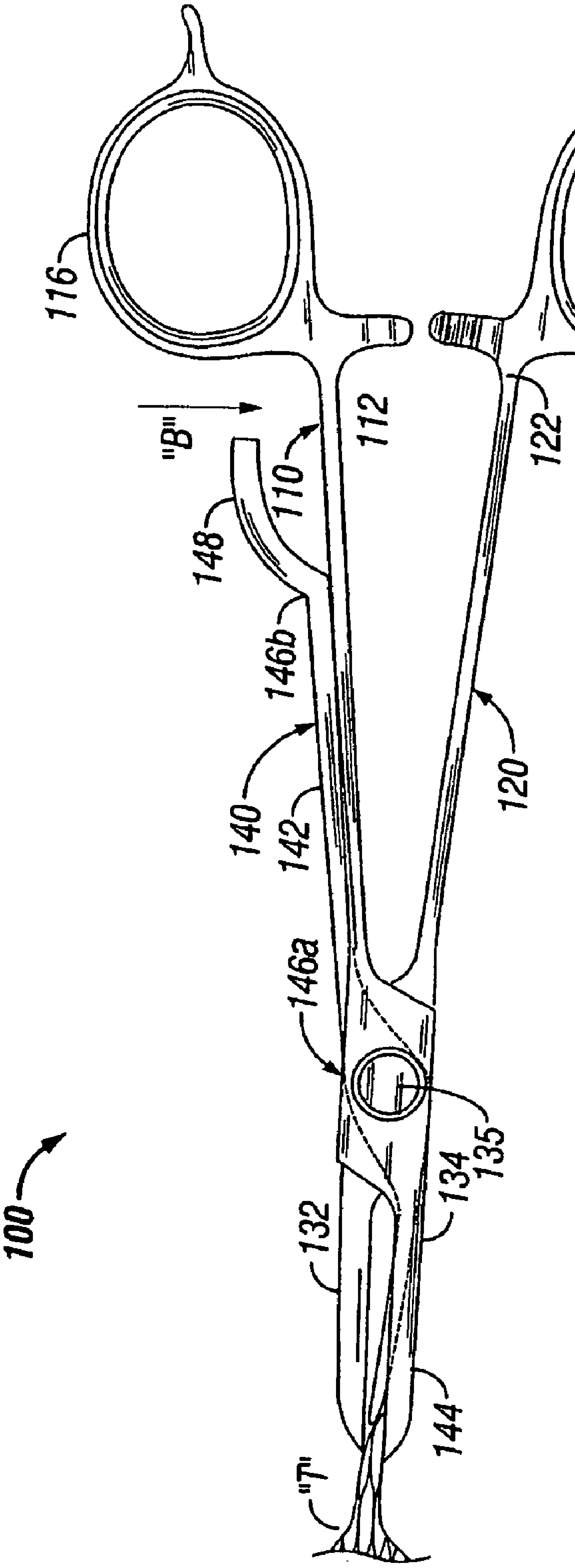
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FIG. 1D

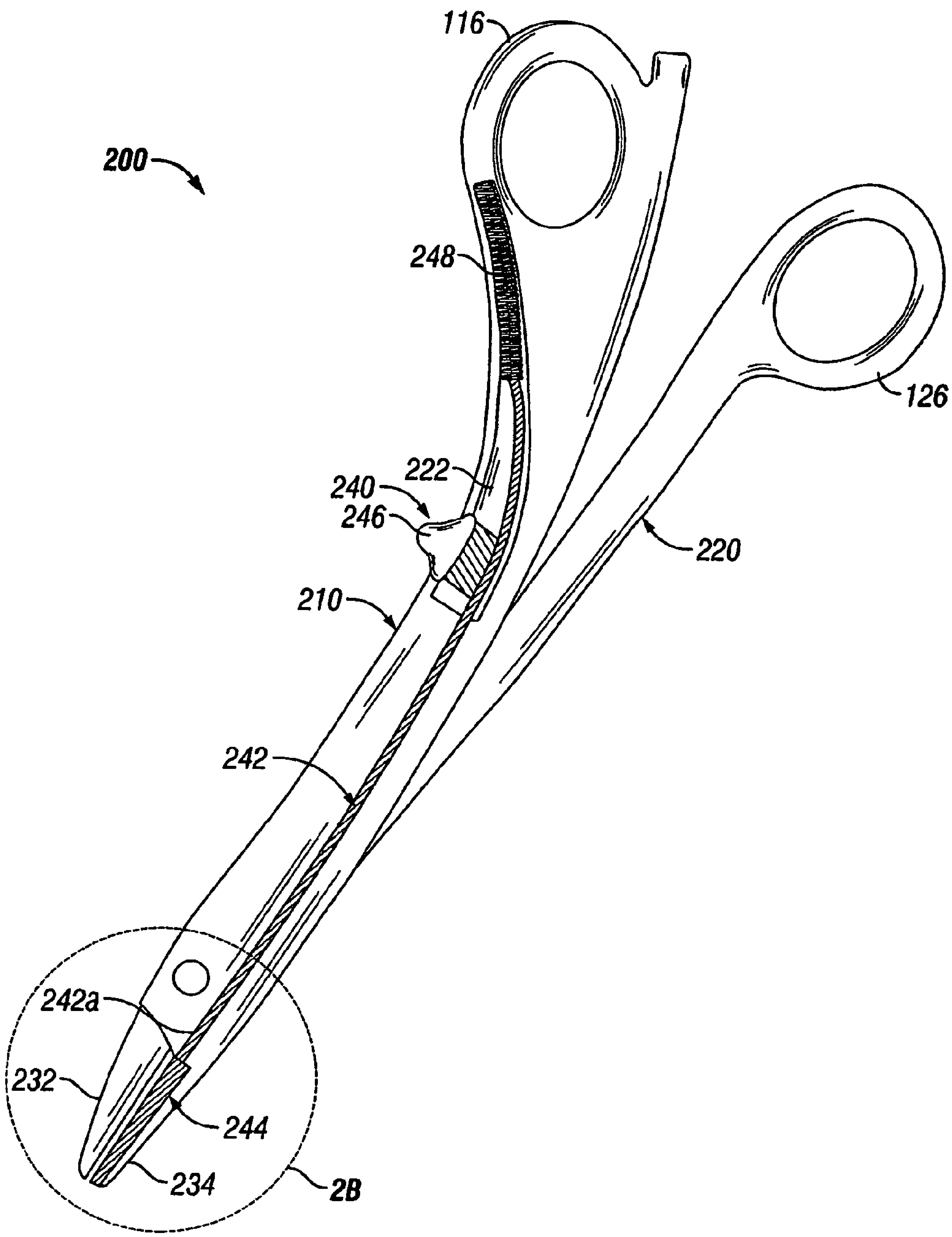

FIG. 2A

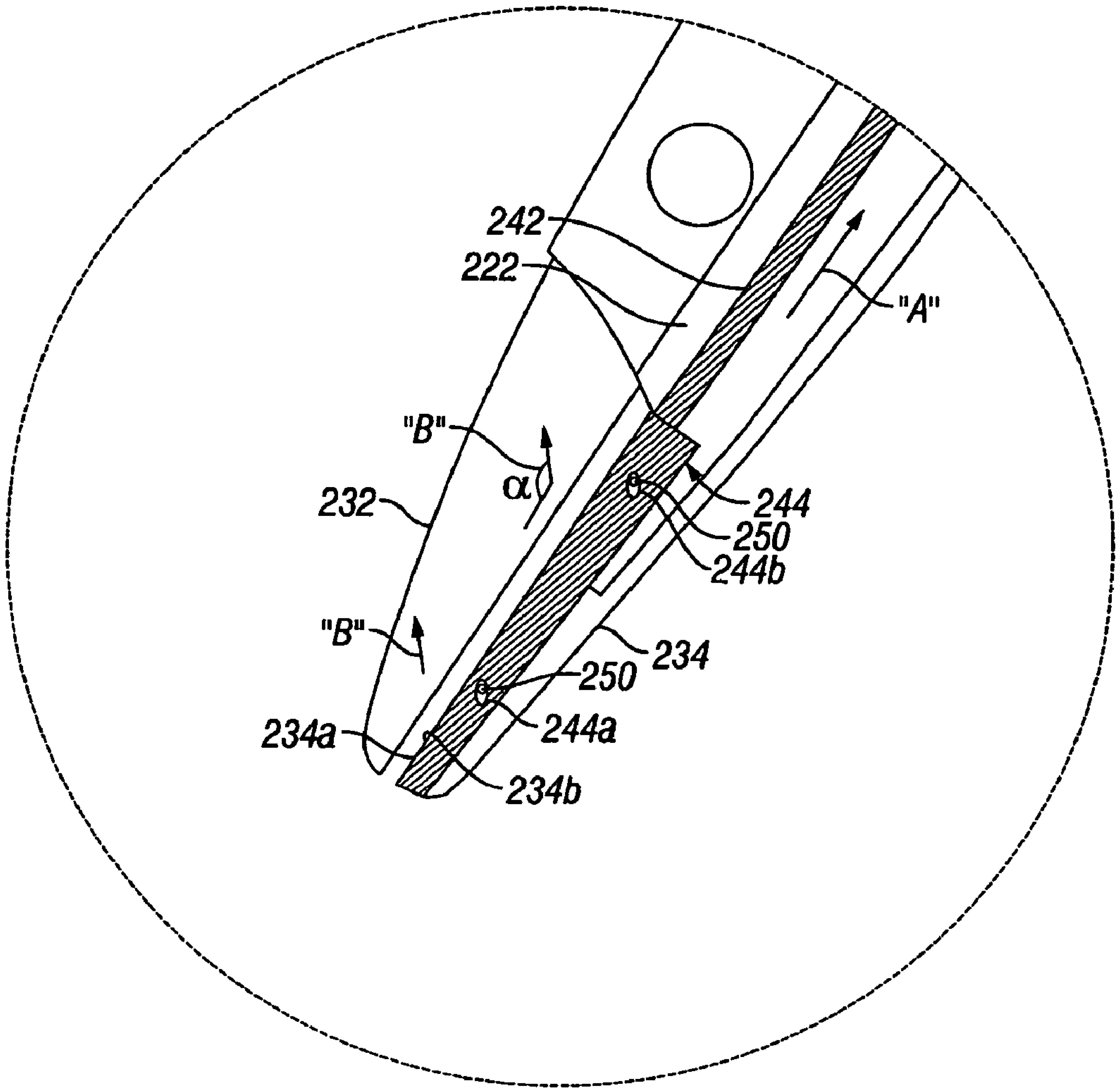

FIG. 2B

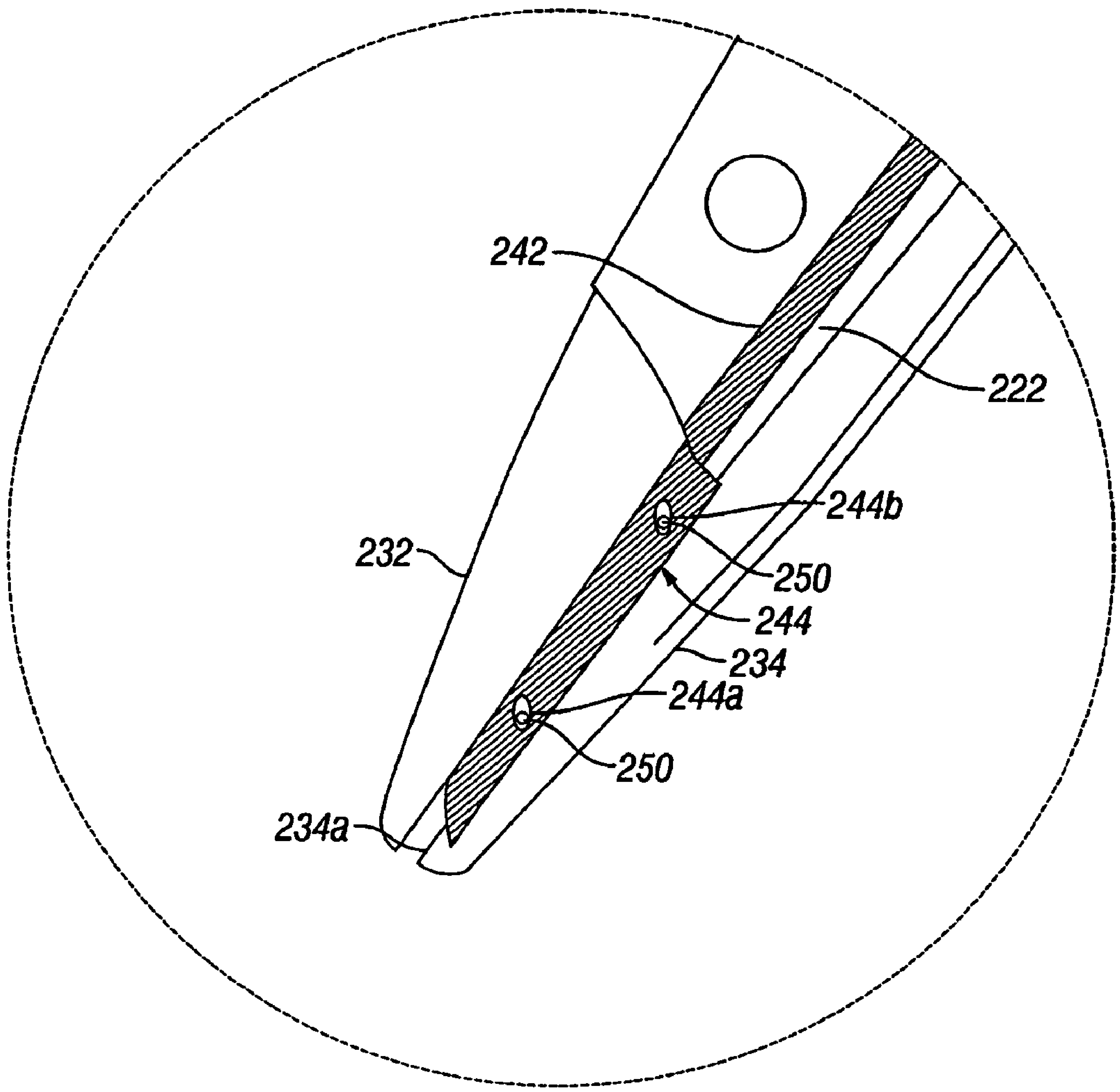

FIG. 2C

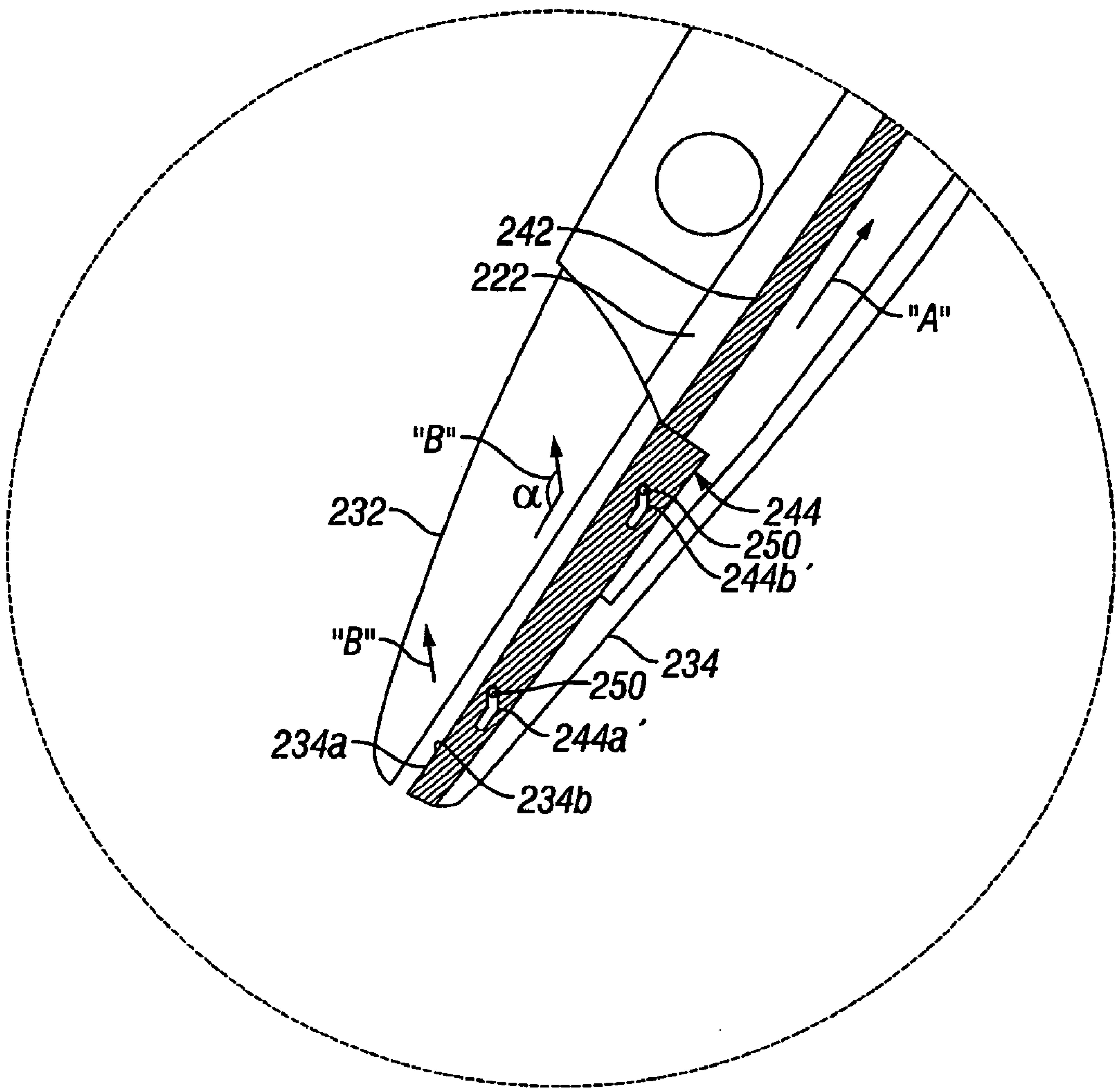

FIG. 2D

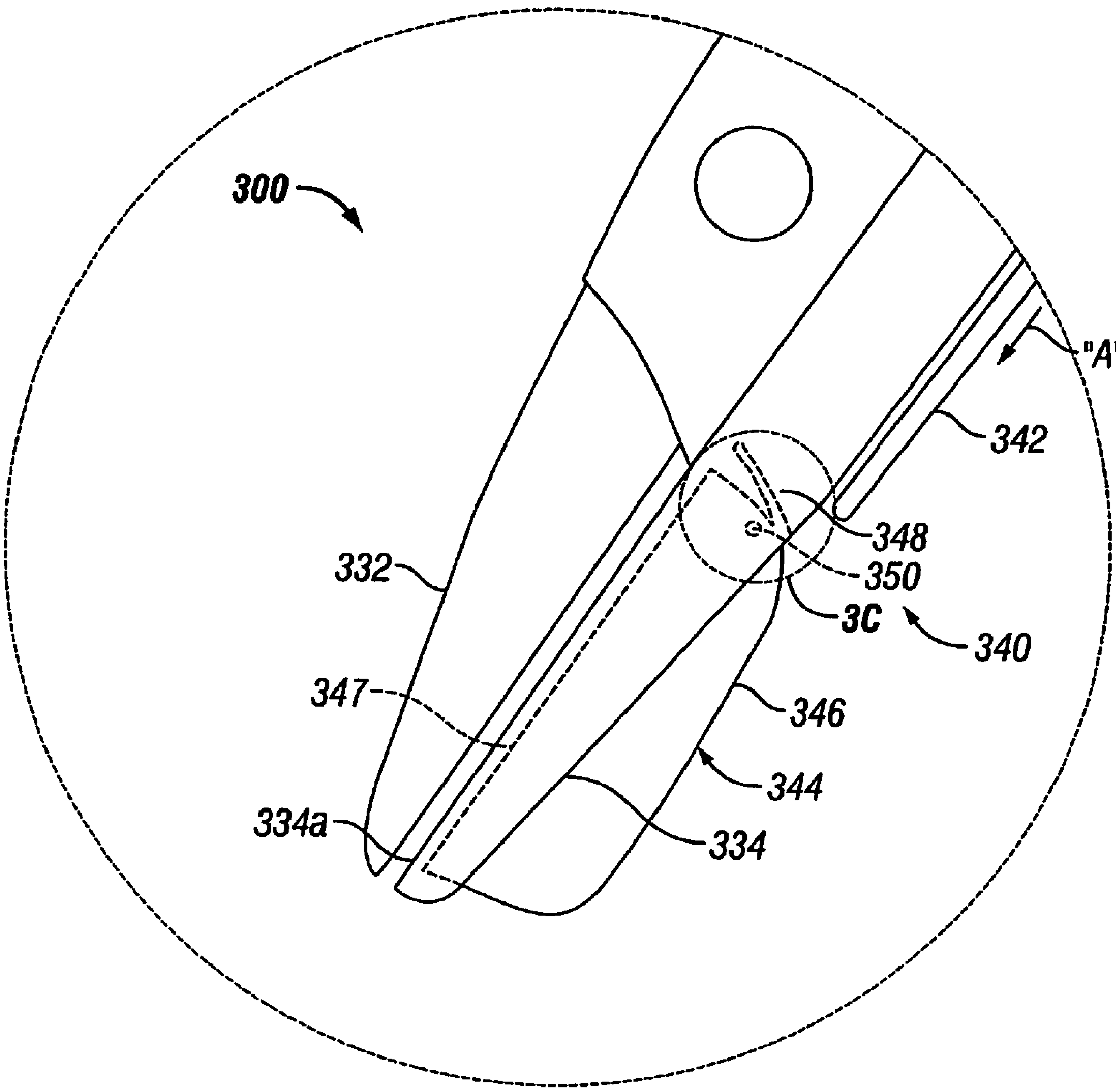

FIG. 3A

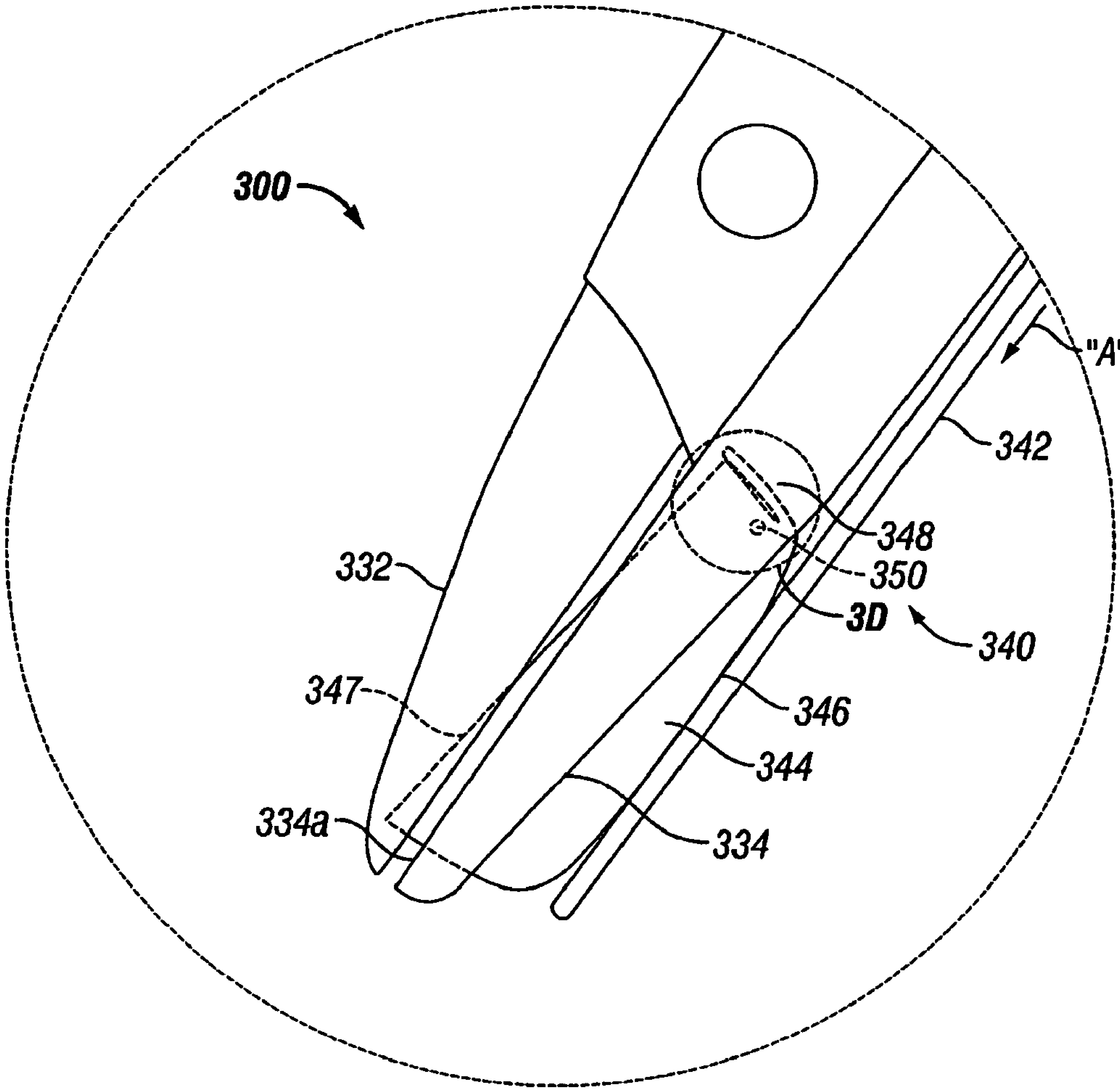

FIG. 3B

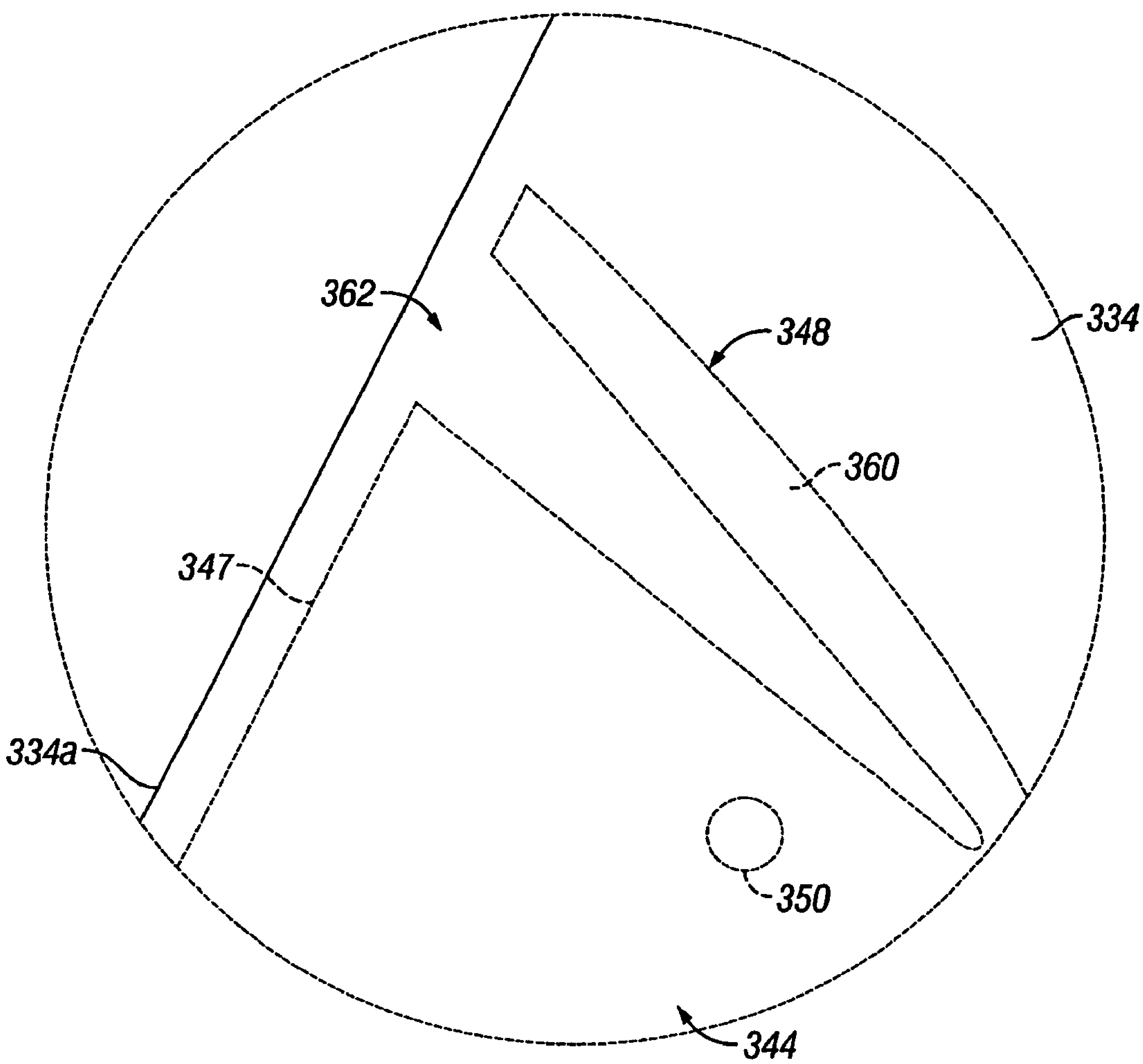

FIG. 3C

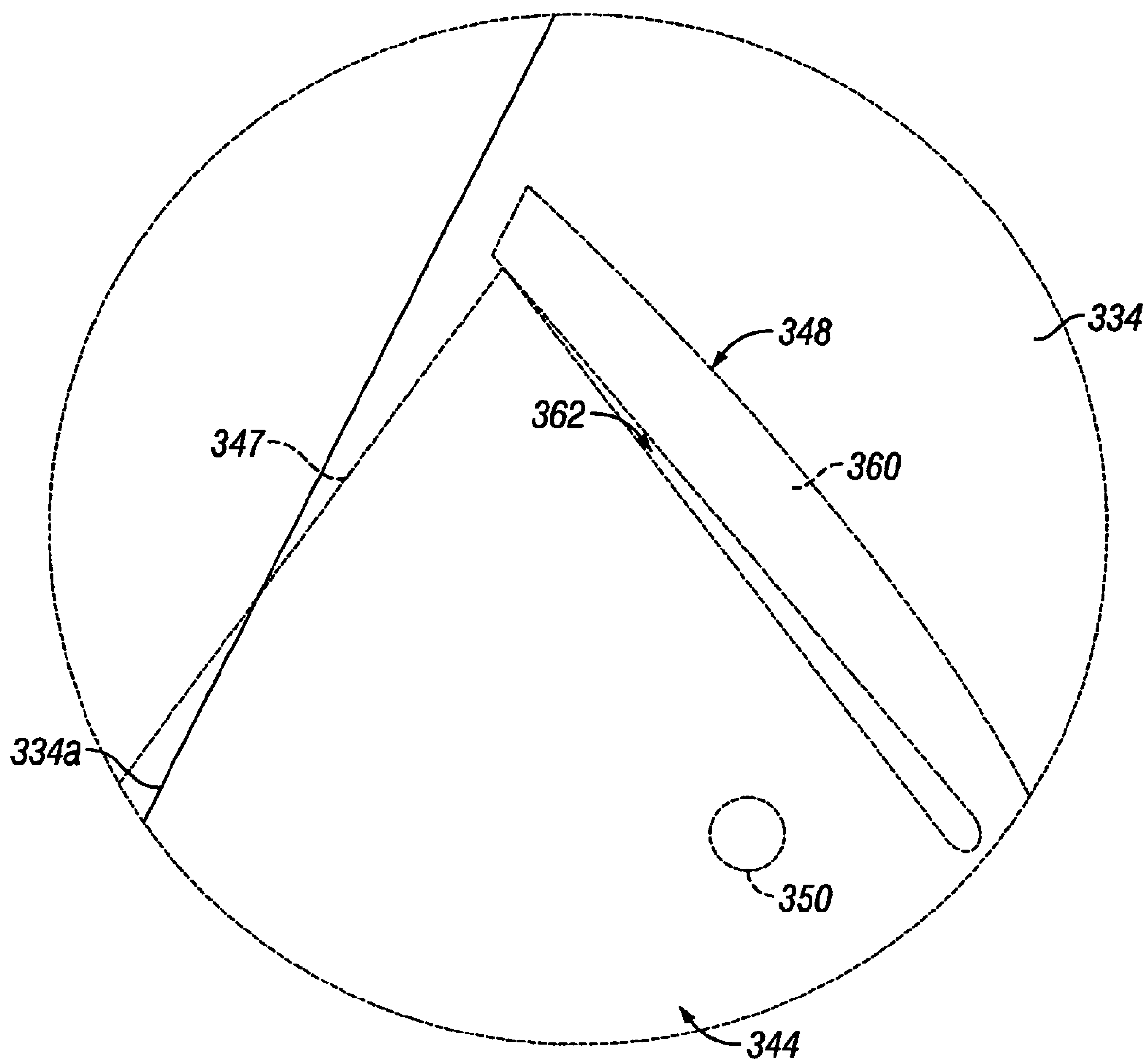

FIG. 3D

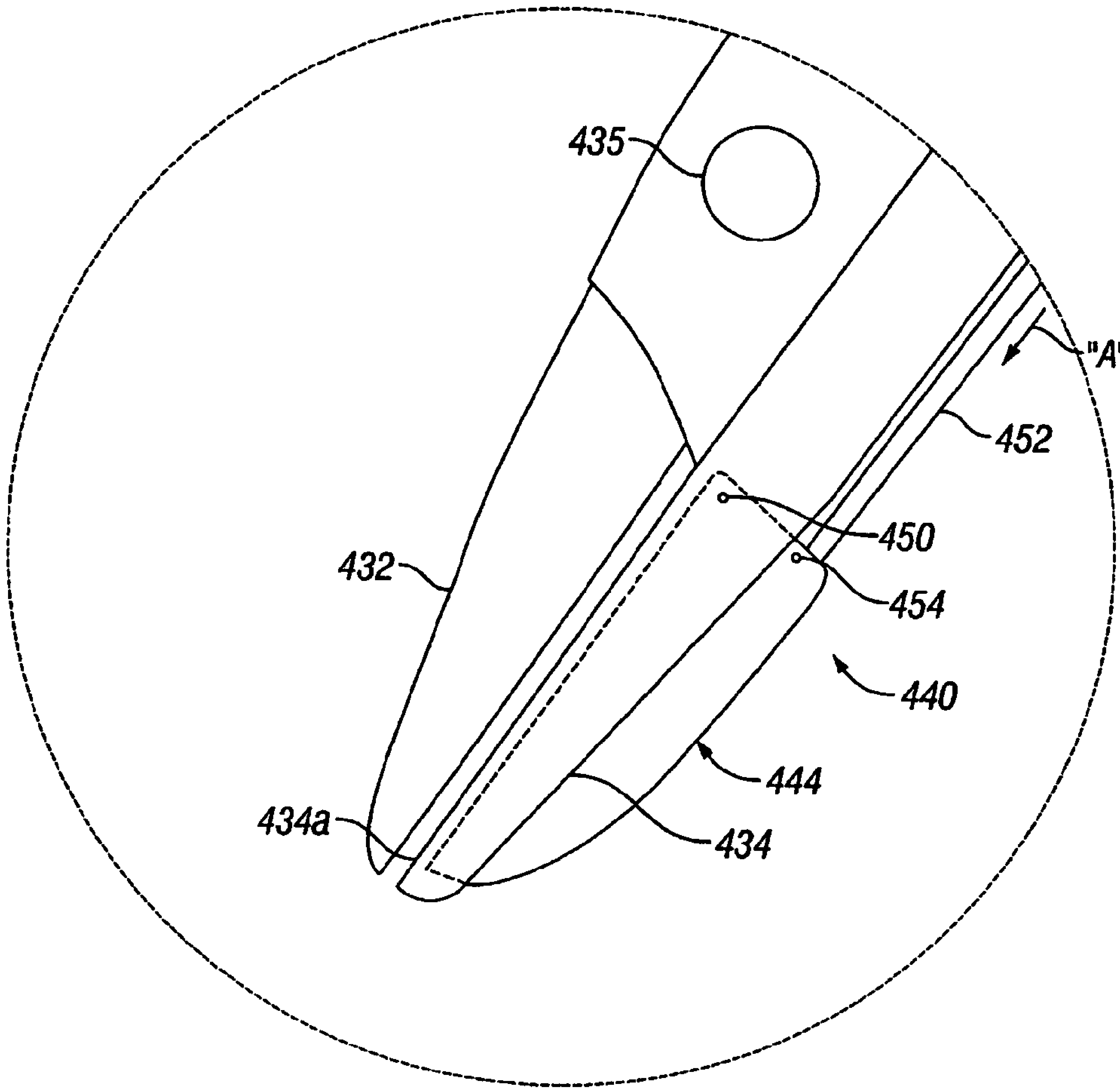

FIG. 4A

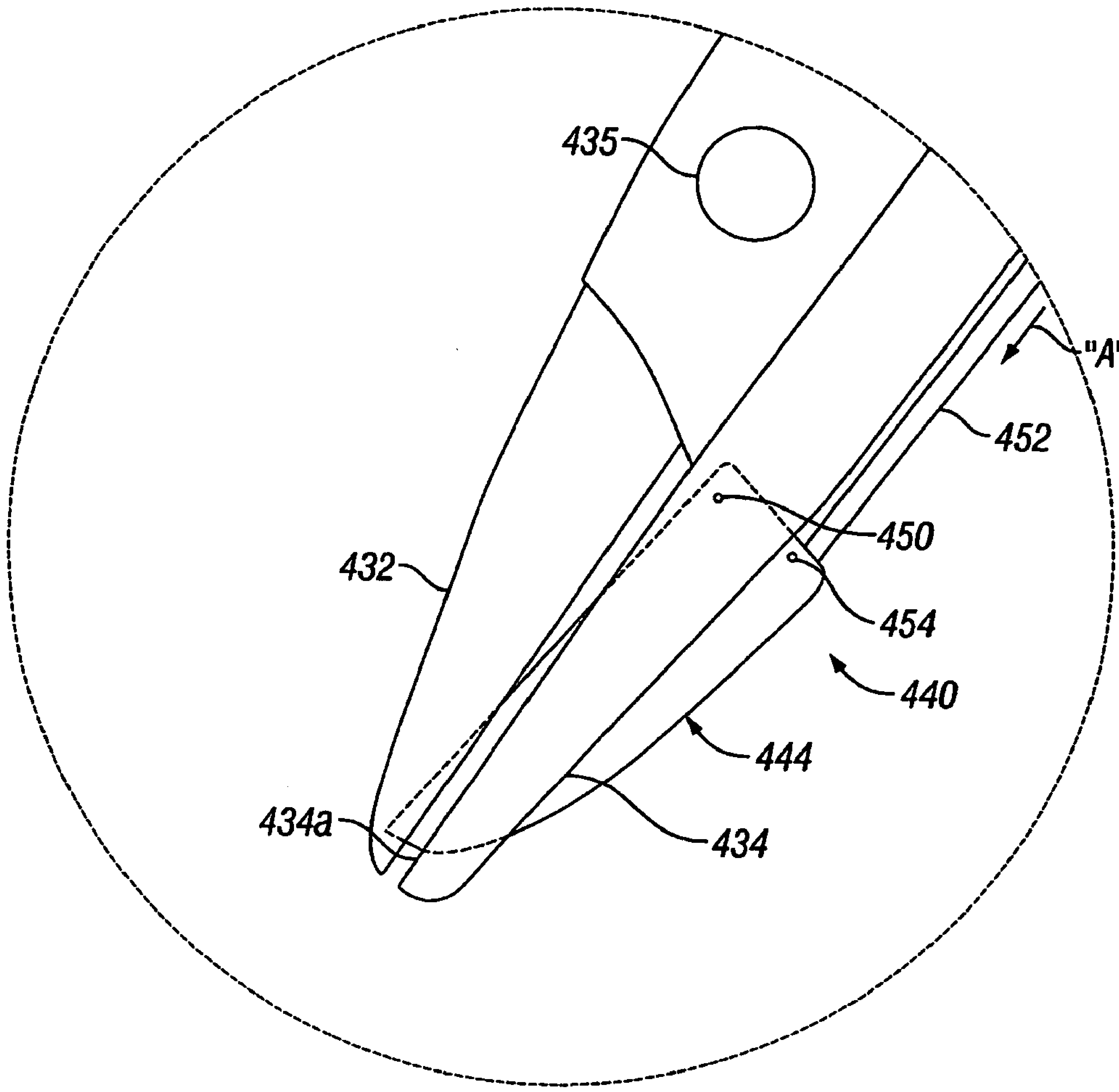

FIG. 4B

MECHANISM FOR DIVIDING TISSUE IN A HEMOSTAT-STYLE INSTRUMENT

CROSS REFERENCE TO RELATED APPLICATION

This application claims the benefit of priority to U.S. Provisional Application Ser. No. 60/616,968 filed on Oct. 8, 2004 entitled "MECHANISM FOR DIVIDING TISSUE IN A HEMOSTAT-STYLE INSTRUMENT" the entire contents of which being incorporated by reference herein.

BACKGROUND

The present disclosure relates to forceps used for open surgical procedures. More particularly, the present disclosure relates to an open forceps which applies a combination of mechanical clamping pressure and electrosurgical energy to seal tissue and a cutting device which is selectively activatable to sever tissue.

TECHNICAL FIELD

A forceps is a plier-like instrument which relies on mechanical action between its jaws to grasp, clamp and constrict vessels or tissue therebetween. So-called "open forceps" are commonly used in open surgical procedures whereas "endoscopic forceps" or "laparoscopic forceps" are, as the name implies, used for less invasive endoscopic surgical procedures. Electrosurgical forceps (open or endoscopic) utilize both mechanical clamping action and electrical energy to effect hemostasis by heating tissue and blood vessels to coagulate and/or cauterize tissue.

Certain surgical procedures require more than simply cauterizing tissue and rely on the unique combination of clamping pressure, precisely controlling the application of electrosurgical energy and the gap distance (i.e., distance between opposing jaw members or opposing conducting surfaces when closed about tissue) to "seal" tissue, vessels and certain vascular bundles.

Vessel sealing or tissue sealing is a recently-developed technology which utilizes a unique combination of radiofrequency energy, pressure and gap control to effectively seal or fuse tissue between two opposing jaw members or sealing plates. Vessel or tissue sealing is more than "cauterization" which is defined as the use of heat to destroy tissue (also called "diathermy" or "electrodiathermy") and vessel sealing is more than "coagulation" which is defined as a process of desiccating tissue wherein the tissue cells are ruptured and dried. "Vessel sealing" is defined as the process of liquefying the collagen, elastin and ground substances in the tissue so that it reforms into a fused mass with significantly-reduced demarcation between the opposing tissue structures.

In order to effectively "seal" tissue or vessels, two predominant mechanical parameters must be accurately controlled: 1) the pressure applied to the vessel or tissue; and 2) the gap distance between the conductive tissue contacting surfaces (electrodes). As can be appreciated, both of these parameters are affected by the thickness of the tissue being sealed. Accurate application of pressure is important for several reasons: to reduce the tissue impedance to a low enough value that allows enough electrosurgical energy through the tissue; to overcome the forces of expansion during tissue heating; and to contribute to the end tissue thickness which is an indication of a good seal. It has been determined that a good seal for certain tissues is optimum between 0.001 inches and 0.006 inches.

With respect to smaller vessels or tissue, the pressure applied becomes less relevant and the gap distance between the electrically conductive surfaces becomes more significant for effective sealing. In other words, the chances of the two electrically conductive surfaces touching during activation increases as the tissue thickness and the vessels become smaller.

Commonly owned, U.S. Pat. No. 6,511,480, PCT Patent Application Nos. PCT/US01/11420 and PCT/US01/11218, U.S. patent application Ser. Nos. 10/116,824, 10/284,562 and 10/299,650 all describe various open surgical forceps which seal tissue and vessels. All of these references are hereby incorporated by reference herein. In addition, several journal articles have disclosed methods for sealing small blood vessels using electrosurgery. An article entitled Studies on Coagulation and the Development of an Automatic Computerized Bipolar Coagulator, J. Neurosurg., Volume 75, July 1991, describes a bipolar coagulator which is used to seal small blood vessels. The article states that it is not possible to safely coagulate arteries with a diameter larger than 2 to 2.5 mm. A second article is entitled Automatically Controlled Bipolar Electrocoagulation—"COA-COMP", Neurosurg. Rev. (1984), pp. 187-190, describes a method for terminating electrosurgical power to the vessel so that charring of the vessel walls can be avoided.

Typically and particularly with respect to open electrosurgical procedures, once a vessel is sealed, the surgeon has to remove the sealing instrument from the operative site, substitute a new instrument and accurately sever the vessel along the newly formed tissue seal. As can be appreciated, this additional step may be both time consuming (particularly when sealing a significant number of vessels) and may contribute to imprecise separation of the tissue along the sealing line due to the misalignment or misplacement of the severing instrument along the center of the tissue sealing line.

Many endoscopic vessel sealing instruments have been designed which incorporate a knife or blade member which effectively severs the tissue after forming a tissue seal. For example, commonly-owned U.S. application Ser. Nos. 10/116,944; 10/179,863; and 10/460,926 all describe endoscopic instruments which effectively seals and cuts tissue along the tissue seal. Other instruments include blade members or shearing members which simply cut tissue in a mechanical and/or electromechanical manner and are relatively ineffective for vessel sealing purposes.

There exists a need to develop an open electrosurgical forceps which is simple, reliable and inexpensive to manufacture and which effectively seals tissue and vessels and which allows a surgeon to utilize the same instrument to effectively sever the tissue along the newly formed tissue seal.

SUMMARY

Forceps for use in open surgical procedures are provided. According to one aspect of the present disclosure, an open electrosurgical forceps for sealing tissue is provided. The forceps includes first and second shaft portions pivotably associated with one another. Each shaft portion has a jaw member disposed at a distal end thereof. The jaw members are movable from a first position in spaced relation relative to one another to at least one subsequent position wherein the jaw members cooperate to grasp tissue therebetween. Each of the jaw members includes an electrically conductive sealing surface for communicating electrosurgical energy through tissue held therebetween. At least one of the jaw members includes a slot formed through the sealing surface thereof.

The forceps further includes a cutting mechanism operatively associated with the first and second jaw members. The cutting mechanism includes a cutting element disposed within the slot of the at least one jaw member. The cutting element is movable from a first position wherein the cutting element is retracted within the slot of the at least one jaw member and a second position in which the cutting element at least partially projects from the sealing surface of the at least one jaw member. The cutting mechanism further includes an actuator operatively associated with the cutting element which upon movement thereof selectively advances the cutting element from the first position to the second positions.

In one embodiment, the actuator is integrally associated with the cutting element. The cutting mechanism is pivotable about a pivot which connects the first and second jaw members. The actuator is spaced a distance from the first shaft portion. The actuator selectively activates the cutting element when moved relative to the first shaft portion.

In another embodiment, the cutting mechanism may include a drive rod extending through a channel formed in at least one of the first and second shaft portions. The drive rod includes a distal end operatively connected to the cutting element. The cutting mechanism may further include a tab operatively connected to the drive rod for manipulating the drive rod to urge the cutting element between the first and second positions.

The cutting element is supported in the slot of the jaw member such that proximal displacement of the drive rod urges the cutting element from within the slot of the jaw member to cut tissue. Desirably, the cutting element includes at least one angled slot defined therethrough which receives a pivot pin fixed to one of the jaw members.

In one embodiment, each angled slot formed in the cutting element includes a first portion in close proximity to the sealing surface and a second portion extending distally and away from the sealing surface. Proximal movement of the drive rod urges the cutting element from the first position to the second position by a camming action between the pin and the slot formed in the cutting element.

The open electrosurgical forceps may further include a biasing element for urging the drive rod to a distal-most position. The cutting element is pivotably disposed within the slot of the jaw member. The cutting element projects out through the jaw member and defines a camming surface.

In one embodiment, the second shaft portion reciprocably supports the actuator. The actuator is movable from a first position spaced from the cutting element to a second position in contact with the cutting element. In use, displacement of the actuator from the first position to the second position, the actuator engages the camming surface of the cutting element and urges the cutting element from the first position to the second position.

The open electrosurgical forceps may further include a biasing element for urging the cutting element to the first position. It is envisioned that movement of the actuator pivots the cutting element between the first and second positions.

According to another aspect of the present disclosure, the open electrosurgical forceps may include a pair of shaft portions pivotably coupled to one another at a pivot point. Each shaft portion includes a jaw member at a distal end thereof for grasping tissue therebetween. Each jaw member includes a sealing surface for conducting electrosurgical energy through tissue grasped therebetween and one of the sealing surfaces has a slot formed therein. The forceps further includes a cutting mechanism operatively coupled to the shaft portions and has a cutting element operatively secured proximate the distal end of the forceps. The cutting mechanism is selectively movable from a first position in which the cutting element is retracted within the slot and a second position in which the cutting element at least partially projects from the slot to cut tissue disposed between the jaw members.

In one embodiment, the cutting mechanism includes a drive rod extending through a channel formed in at least one of the first and second shaft portions. The drive rod includes a distal end operatively connected to the cutting element. The cutting mechanism further includes a tab operatively connected to the drive rod for manipulating the drive rod to urge the cutting element between the first and second positions.

The cutting element is operatively engaged in the slot of the one jaw member such that axial displacement of the drive rod results in transverse displacement of the cutting element from the slot to cut tissue disposed between jaw members.

DESCRIPTION OF THE DRAWINGS

Various embodiments of the present disclosure are described with reference to the following drawing figures. It should be understood, however, that the drawings are designed for the purpose of illustration only and not as a definition of the limits of the invention.

FIG. **1**A is a perspective view of a forceps according to one embodiment of the present disclosure;

FIG. **1**B is a side, elevational view of the forceps of FIG. **1**A shown in an open position;

FIG. **1**C is a side, elevational view of the forceps of FIGS. **1**A and **1**B shown in a closed position and the cutting assembly shown in an unactuated position;

FIG. **1**D is a side, elevational view of the forceps of FIGS. **1**A-**1**C shown in a closed position and the cutting assembly shown in an actuated position;

FIG. **2**A is a cross-sectional, side elevational view of an alternate embodiment of a forceps according to the present disclosure;

FIG. **2**B is an enlarged view of the indicated area of detail of FIG. **2**A, illustrating a cutting element of the forceps in a first position;

FIG. **2**C is an enlarged view of the indicated area of detail of FIG. **2**A, illustrating the cutting element of the forceps in a second position;

FIG. **2**D is an enlarged view of the indicated area of detail of FIG. **2**A, illustrating a cutting element of the forceps according to an alternate embodiment of the disclosure;

FIG. **3**A is an enlarged, schematic side elevational view of a distal end of a forceps constructed according to another embodiment of the present disclosure, illustrating a cutting assembly in a first position;

FIG. **3**B is an enlarged, schematic side elevational view of the distal end of the forceps of FIG. **3**A, illustrating the cutting assembly in a second position;

FIG. **3**C is an enlarged, schematic view of an alternate biasing arrangement for the cutting assembly shown in a first position;

FIG. **3**D is an enlarged, schematic view of an alternate biasing arrangement of FIG. **3**C in a second position;

FIG. **4**A is an enlarged schematic side elevational view of a distal end of a forceps constructed according to yet another embodiment of the present disclosure, illustrating a cutting assembly in a first position; and

FIG. **4**B is an enlarged schematic side elevational view of the distal end of the forceps of FIG. **4**A, illustrating the cutting assembly in a second position.

DETAILED DESCRIPTION

Referring now to FIGS. **1**A-**1**D, a forceps or hemostat for use in open surgical procedures is generally designated as

100. Forceps **100** includes a first elongated shaft portion **110** and a second elongated shaft portion **120** each having a proximal end **112** and **122**, respectively. In the drawings and in the descriptions which follow, the term "proximal", as is traditional, will refer to the end of forceps **100** which is closer to the user, while the term "distal" will refer to the end which is further from the user.

Forceps **100** includes an end effector assembly **130** which attaches to distal ends **114**, **124** of shaft portions **110**, **120**, respectively. As explained in more detail below, end effector assembly **130** includes a pair of opposing jaw members **132**, **134** which are pivotably connected about a pivot pin **135** and which are movable relative to one another to grasp tissue therebetween.

Each shaft portion **110** and **120** includes a handle **116**, **126**, respectively, disposed at proximal ends **112**, **122**, thereof. Each handle **116**, **126** defines a finger hole **116*a***, **126*a***, respectively, therethrough for receiving a finger of the user. As can be appreciated, finger holes **116*a***, **126*a***, facilitate movement of shaft portions **110** and **120** relative to one another which, in turn, pivot the jaw members **132** and **134**, about pivot pin **135**, from an open position wherein the jaw members **132** and **134** are disposed in spaced relation relative to one another to a clamping or closed position wherein jaw members **132** and **134** cooperate to grasp tissue therebetween.

Shaft portions **110**, **120** are designed to transmit a particular desired force to the opposing sealing surfaces **132*a***, **134*a*** of jaw members **132**, **134**, respectively, when clamped. In particular, since shaft portions **110**, **120** effectively act together in a spring-like manner (i.e., bending that behaves like a spring), the length, width, height and deflection of shaft portions **110**, **120** will directly effect the overall transmitted force imposed on opposing jaw members **132**, **134**. Jaw members **132**, **134** are more rigid than shaft portions **110**, **120** and the strain energy stored in the shaft portions **110**, **120** provides a constant closure force between jaw members **132**, **134**.

Each shaft portion **110**, **120** also includes a ratchet portion **118**, **128**. Each ratchet, e.g., **118**, extends from a proximal end of its respective shaft portion **110** towards the other ratchet **128** in a generally vertically aligned manner. The inner facing surfaces of each ratchet **118**, **128** includes a plurality of flanges **118*a***, **128*a***, respectively, which project from the inner facing surface of each ratchet **118**, **128** such that the ratchets **118**, **128** can interlock in at least one position. In the embodiment shown in FIG. **1**A, ratchets **118**, **128** interlock at several different positions. Each ratchet position holds a specific, i.e., constant, strain energy in shaft portions **110**, **120** which, in turn, transmits a specific force to jaw members **132**, **134**.

One of the shaft portions, e.g., shaft portion **120**, includes a proximal shaft connector **150** which is designed to connect forceps **100** to a source of electrosurgical energy, e.g., an electrosurgical generator (not shown). Connector **150** electromechanically engages a conducting cable **152** such that the user may selectively apply electrosurgical energy as needed.

As briefly discussed above, jaw members **132**, **134** are selectively movable about pivot pin **135** from the open position to the closed position for grasping tissue therebetween. Jaw members **132** and **134** are generally symmetrical and include similar component features which cooperate to permit facile rotation about pivot pin **135** to effect the grasping and sealing of tissue. As a result and unless otherwise noted, jaw member **132** and the operative features associated therewith are initially described herein in detail and the similar component features with respect to jaw member **134** will be briefly summarized thereafter. Moreover, many of the features of jaw members **132** and **134** are described in detail in commonly-owned U.S. patent application Ser. Nos. 10/284, 562, 10/116,824, 09/425,696, 09/178,027 and PCT Application Ser. No. PCT/US01/11420 the contents of which are all hereby incorporated by reference in their entirety herein.

Jaw member **132** includes an electrically conductive sealing surface **132*a*** which conducts electrosurgical energy of a first potential to the tissue upon activation of forceps **100**. Exemplary embodiments of conductive sealing surface **132*a*** are discussed in commonly-owned, co-pending PCT Application Serial No. PCT/US01/11412 and commonly owned, co-pending PCT Application Serial No. PCT/US01/11411, the contents of both of these applications being incorporated by reference herein in their entirety.

Similar to jaw member **132**, jaw member **134** includes an electrically conductive sealing surface **134*a*** for conducting electrosurgical energy of a second potential to the tissue upon activation of forceps **100**.

It is envisioned that one of the jaw members, e.g., **132**, includes at least one stop member (not shown) disposed on the inner facing surface of the electrically conductive sealing surface **132*a*** (and/or **134*a***). Alternatively or in addition, the stop member(s) may be positioned adjacent to the electrically conductive sealing surfaces **132*a***, **134*a*** or proximate the pivot pin **135**. The stop member(s) is/are designed to define a gap between opposing jaw members **132** and **134** during sealing. The separation distance during sealing or the gap distance is within the range of about 0.001 inches (~0.03 millimeters) to about 0.006 inches (~0.016 millimeters).

A detailed discussion of these and other envisioned stop members as well as various manufacturing and assembling processes for attaching, disposing, depositing and/or affixing the stop members to the electrically conductive sealing surfaces **132*a***, **134*a*** are described in commonly-assigned, co-pending PCT Application Serial No. PCT/US01/11222 and U.S. application Ser. No. 10/471,818 which are both hereby incorporated by reference in their entirety herein.

As mentioned above, two mechanical factors play an important role in determining the resulting thickness of the sealed tissue and effectiveness of the seal, i.e., the pressure applied between opposing jaw members **132** and **134** and the size of the gap between opposing jaw members **132** and **134** (or opposing sealing surface **132*a*** and **134*a*** during activation). It is known that the thickness of the resulting tissue seal cannot be adequately controlled by force alone. In other words, too much force and jaw members **132** and **134** may touch and possibly short resulting in little energy traveling through the tissue thus resulting in an inadequate seal. Too little force and the seal would be too thick. Applying the correct force is also important for other reasons: to oppose the walls of the vessel; to reduce the tissue impedance to a low enough value that allows enough current through the tissue; and to overcome the forces of expansion during tissue heating in addition to contributing towards creating the required end tissue thickness which is an indication of a good seal.

Sealing surfaces **132*a*** and **134*a*** are relatively flat to avoid current concentrations at sharp edges and to avoid arcing between high points. In addition, and due to the reaction force of the tissue when engaged, jaw members **132** and **134** are manufactured to resist bending, i.e., tapered along their length to provide a constant pressure for a constant tissue thickness at parallel and the thicker proximal portion of jaw members **132** and **134** will resist bending due to the reaction force of the tissue.

As best shown in FIGS. **1**A-**1**D, forceps **100** further includes a cutting mechanism **140** operatively associated therewith. Cutting mechanism **140** includes an arm portion **142** pivotably connected to one of the first and second shaft portions **110**, **120**, a cutting element **144** (e.g., blade, knife, scalpel, etc.) disposed at a distal end **146***a* thereof, and a finger gripping element **148** disposed at a proximal end **146***b* thereof.

Cutting mechanism **140** is pivotably coupled to shaft portion **110** about pivot pin **135**. Cutting mechanism **140** is pivotably coupled to shaft portion **110** in such a manner that cutting element **144** is biased (via a spring or the like) in a retracted position within a slot **134***b* defined in sealing surface **134***a* of jaw member **134**. Cutting mechanism **140** is selectively movable about pivot pin **135** to deploy cutting element **144** from within slot **134***b* to cut tissue. Cutting element **144** may also be movably retractable depending upon a particular purpose.

In particular, cutting mechanism **140** is pivotable from a first position in which cutting element **144** is retained at least substantially within slot **134***b* of jaw member **134** to a second position in which cutting element **144** is deployed from jaw member **134**. When cutting element **144** is disposed in jaw member **134**, arm portion **142** of cutting assembly **142** is spaced a distance from shaft portion **110**.

With reference to FIGS. **1**B-**1**D, a method of using forceps **100** will now be described in detail. As seen in FIG. **1**B, with shaft portions **110**, **120** in the open position, such that jaw members **132**, **134** are spaced from one another, and with cutting assembly **140** in the first position (i.e., within slot **134***b*), jaw members **132**, **134** are maneuvered around the target tissue "T". As seen in FIG. **1**C, following manipulation and positioning of jaw members **132**, **134** about target tissue "T", forceps **100** is moved from the open position to the closed position. In particular, proximal ends **112**, **122** of shaft portions **110** and **120** are moved toward one another, in the direction of arrows "A", to thereby proximate jaw members **132**, **134** toward one another.

In so doing, target tissue "T" is clamped or grasped between jaw members **132**, **134**. Desirably, the user then activates a hand switch or a foot switch (not shown) to provide electrosurgical energy to each jaw member **132**, **134** to communicate energy through target tissue "T" held therebetween to effect a tissue seal. Once target tissue "T" is sealed, as seen in FIG. **1**D, cutting mechanism **140** is actuated, e.g., arm portion **142** is moved toward shaft portion **110** in the direction of arrow "B", to sever target tissue "T" along the tissue seal. In particular, upon movement of arm portion **142** cutting element **144** pivots about pivot pin **135** and deploys from jaw member **134** toward jaw member **132** to thereby slice, cut and/or otherwise divide target tissue "T" along the previously formed tissue seal.

Turing now to FIGS. **2**A-**2**C, a forceps in accordance with another embodiment of the present disclosure is shown generally as **200**. Forceps **200** is similar to forceps **100** and will only be described in detail to the extent necessary to identify differences in construction and operation.

Forceps **200** includes a cutting mechanism **240** operatively associated therewith. Cutting mechanism **240** includes a drive rod **242** for advancing cutting mechanism **240** through shaft portion **210**, which will be explained in greater detail below. Drive rod **242** includes a distal end **242***a* configured to mechanically support a cutting element **244**. Cutting element **244** is disposed in slot **234***b* formed in seal surface **234***a* of jaw member **234** (see FIG. **2**B). Cutting mechanism **240** further includes a finger tab **246** operatively associated with drive rod **242** such that movement of finger tab **246** moves drive rod **242** in the corresponding direction.

Shaft portion **210** includes at least one guide channel **222** formed therein for controlling and/or guiding drive rod **242** through movement therethrough. Drive rod **242** is made from a flexible wire or plastic sheath which does not buckle upon movement thereof.

A spring **248** may be employed within guide channel **222** to bias cutting mechanism **240** back to the unactuated position upon proximal movement of tab **246** such that upon release of finger tab **246**, the force of spring **248** automatically returns cutting mechanism **240** to its distal-most position within guide channel **222** which, in turn, retracts cutting element **244** within slot **234**. While a spring **248** is shown for maintaining cutting mechanism **240** in a distal-most position, it is envisioned and within the scope of the present disclosure that a spring, e.g., a coil spring, (not shown) can be operatively associated therewith for maintaining cutting mechanism **240** in a proximal-most position and wherein finger tab **246** is positioned so as to drive cutting mechanism **240** in a distal direction.

As best seen in FIGS. **2**B and **2**C, cutting element **244** is provided with at least one elongated slot, preferably a pair of elongated slots **244***a*, **244***b*, formed therein. Slots **244***a*, **244***b* are oriented at an angle with respect to the longitudinal axis of forceps **200**. The portion of slots **244***a*, **244***b* which is closest to seal surface **234***a* of jaw member **234** is located proximal of the portion of slots **244***a*, **244***b* which is furthest from seal surface **234***a* of jaw member **234**.

A pin **250** is provided within each slot **244***a*, **244***b*. Each pin **250** is fixedly positioned relative to jaw member **234**. When cutting element **244** is in a distal-most position, pins **250** are located in the portion of slots **244***a*, **244***b* closest to seal surface **234***a*.

As seen in FIGS. **2**B and **2**C, in operation and following application of electrosurgical energy to jaw members **232**, **234**, to thereby seal the target tissue held therebetween, the user activates finger tab **246** to thereby urge drive rod **242** in a proximal direction, as indicated by arrow "A". In so doing, cutting element **244** is urged in an angular direction relative to the longitudinal axis, as indicated by arrows "B". In particular, cutting element **244** is drawn both proximally and toward jaw member **232** (i.e., deployed from slot **234***b* formed in sealing surface **234***a* of jaw member **234**, to thereby slice the target tissue which is clamped between jaw members **232**, **234**. In other words, cutting element **244** is drawn in direction "B" by the camming action created between slots **244***a*, **244***b* and pins **250**. While cam slots **244***a*, **244***b* may be diagonal, as seen in FIG. **2**D, cutting element **244** may be provided with cam slots **244***a*' and **244***b*' having a diagonal portion and a longitudinally extending portion integrally connected to the diagonal portion to thereby by create a slicing or cutting motion for cutting element **244**.

Following the cutting of the target tissue, finger tab **246** may be released to thereby allow the force of spring **248** to automatically return cutting mechanism **240** to its distal-most position within guide channel **222** for subsequent sealing and cutting, which, as mentioned above, retract cutting element **244** to within slot **234***b*.

Turing now to FIGS. **3**A-**3**D, a forceps **300**, having a distal end in accordance with another embodiment of the present disclosure, is shown. Forceps **300** is similar to forceps **100** and **200** and will only be described in detail to the extent necessary to identify differences in construction and operation.

Forceps **300** includes a cutting mechanism **340** operatively associated therewith. Cutting mechanism **340** includes a cutting element **344** disposed in slot **334***b* formed in sealing surface **334***a* of jaw member **334**. Cutting element **344** includes a camming surface **346** at a rear portion thereof, i.e., which extends outwardly from a side opposite sealing surface **334***a* of jaw member **334**.

Cutting element **344** is pivotably supported in slot **334***b* by a pivot pin **350**. A biasing member **348**, e.g., a torsion spring or the like, may be employed within jaw member **334** to bias cutting element **344** in a retracted, i.e., undeployed, condition. Upon at least partial deployment of cutting element **344**, biasing member **348** is biased such that upon release of cutting element **344**, the force of the biasing member **348** automatically returns cutting element **344** into jaw member **334**. Cutting mechanism **340** further includes an advancing sheath **342** operatively associated with forceps **300** for deploying cutting element **344**. Any type of known actuation may be employed to advance sheath **342**.

As seen in FIGS. **3**A and **3**B, following application of electrosurgical energy to jaw members **132**, **134** to seal tissue held therebetween, the user advances sheath **342** a distal direction, as indicated by arrow "A", to engage camming surface **346** of cutting element **344** and urge cutting element **344** out of slot **334***b* in the direction of arrow "B" to sever tissue. Following the cutting of the tissue, sheath **342** is withdrawn in a proximal direction until camming surface **346** of cutting element **344** is disengaged. The force of biasing member **348** automatically returns cutting mechanism **340** into slot **334***b* of jaw member **334**.

Turning now to FIGS. **3**C and **3**D, a detailed discussion of biasing member **348** is provided. As seen in FIG. **3**C, cutting element **344** includes a rear flange or arm **360** which defines a notch **362** formed between a proximal end of cutting element **344** and arm **360**. Notch **362** is located proximal of pin **350**. Notch **362** extends through cutting edge **347** of cutting element **344**. Cutting element **344** is fabricated from spring type steel or any other material exhibiting resilient characteristics.

In operation, as seen in FIGS. **3**C and **3**D, as cutting element **344** is urged out of slot **334***b* of jaw member **334**, in the direction of arrow "B" (FIG. **3**B), notch **362** closes against the bias created by arm **360**. Following the cutting of the target tissue, sheath **342** is withdrawn in a proximal direction until camming surface **346** of cutting element **344** is disengaged. The biasing force created by arm **360** automatically returns cutting mechanism **340** into slot **334***b* of jaw member **334**.

Turning now to FIGS. **4**A and **4**B an alternative embodiment includes a cutting element **444** is pivotably connected to a drive rod **452** by a pin **454**. In this manner, as drive rod **452** is driven in a distal direction, as indicated by arrow "A", cutting element **444** is pivoted about pin **450** and urged out of slot **334***b* of jaw member **334**. Following the cutting step, drive rod **452** is withdrawn in a proximal direction to urge cutting element **444** back into jaw member **334**.

It is envisioned and within the scope of the present disclosure that a biasing member, e.g., a spring, (not shown) may be provided for returning cutting element **444** into jaw member **334** following deployment by drive rod **452**.

It is further envisioned and within the scope of the present disclosure to provide a cutting element **444** configured such that cutting element **444** is pivotable about pivot pin **435**.

It is envisioned that any of the cutting elements disclosed herein may be fabricated from plastic and/or metal (e.g., stainless steel, titanium, etc.). Desirably, the cutting elements are fabricated from non-conductive materials to thereby reduce the potential for stray currents and/or shorting.

From the foregoing and with reference to the various figure drawings, those skilled in the art will appreciate that certain modifications can also be made to the present disclosure without departing from the scope of the same. For example, none of the aforedescribed forceps require that the tissue be necessarily cut after sealing or that the tissue be sealed prior to cutting. As can be appreciated, this gives the user additional flexibility when using the instrument.

For example, it is also contemplated that forceps **100**, **200** and/or **300** (and/or the electrosurgical generator used in connection therewith) may include a sensor or feedback mechanism (not shown) which automatically selects the appropriate amount of electrosurgical energy to effectively seal the particularly-sized tissue grasped between the jaw members. The sensor or feedback mechanism may also measure the impedance across the tissue during sealing and provide an indicator (visual and/or audible) that an effective seal has been created between jaw members **132** and **134**. Commonly-owned U.S. patent application Ser. No. 10/073,761, filed on Feb. 11, 2002, entitled "Vessel Sealing System"; U.S. patent application Ser. No. 10/626,390, filed on Jul. 24, 2003, entitled "Vessel Sealing System"; U.S. patent application Ser. No. 10/427,832, filed on May 1, 2003, entitled "Method and System for Controlling Output of RF Medical Generator"; U.S. patent application Ser. No. 10/761,524, filed on Jan. 21, 2004, entitled "Vessel Sealing System"; U.S. Provisional Application No. 60/539,804, filed on Jan. 27, 2004, entitled "Method of Tissue Fusion of Soft Tissue by Controlling ES Output Along Optimal Impedance Curve"; U.S. Provisional Application No. 60/466,954; filed on May 1, 2003, entitled "Method and System for Programming and Controlling an Electrosurgical Generator System"; and U.S. Pat. No. 6,398,779, disclose several different types of sensory feedback mechanisms and algorithms which may be utilized for this purpose. The contents of these applications are hereby incorporated by reference herein.

Experimental results suggest that the magnitude of pressure exerted on the tissue by the sealing surfaces of jaw members **132** and **134** are important in assuring a proper surgical outcome. Tissue pressures within a working range of about 3 kg/cm^2 to about 16 kg/cm^2 and, desirably, within a working range of 7 kg/cm^2 to 13 kg/cm^2 have been shown to be effective for sealing arteries and vascular bundles. Tissue pressures within the range of about 4 kg/cm^2 to about 6.5 kg/cm^2 have proven to be particularly effective in sealing arteries and particular tissue bundles.

While several embodiments of the disclosure have been shown in the drawings, it is not intended that the disclosure be limited thereto, as it is intended that the disclosure be as broad in scope as the art will allow and that the specification be read likewise. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended hereto.

What is claimed is:

1. An open electrosurgical forceps for sealing tissue, comprising:

first and second shaft portions pivotably associated with one another, each shaft portion having a jaw member disposed at a distal end thereof, the jaw members being movable from a first position in spaced relation relative to one another to at least one subsequent position wherein the jaw members cooperate to grasp tissue therebetween, each of the jaw members including an electrically conductive sealing surface being configured to communicate electrosurgical energy through tissue held therebetween, at least one of the jaw members including a slot formed through the sealing surface thereof;

a cutting mechanism operatively associated with the first and second jaw members, the cutting mechanism including:

a cutting element disposed within the slot of the at least one jaw member, the cutting element being movable about a pivot from a first position wherein the cutting element is retracted within the at least one jaw member and a second position in which a cutting edge of the cutting element at least partially projects from a sealing surface of the at least one jaw member, the cutting element including a biasing member at a proximal end thereof, the biasing member operably disposed within the jaw member and configured for biasing the cutting element toward the first position and pivoting the cutting element, the biasing member including a notched portion configured to facilitate pivoting the cutting element between the first and second positions, the notched portion disposed proximal relative to the pivot and extending to the cutting edge of the cutting element; and

an actuator operatively associated with the cutting element which upon movement thereof selectively advances the cutting element from the first position to the second position.

2. The open electrosurgical forceps according to claim **1**, wherein the cutting element is pivotably disposed within the slot of the jaw member.

3. The open electrosurgical forceps according to claim **1**, wherein the cutting element extends out through the jaw member and defines a camming surface.

4. The open electrosurgical forceps according to claim **3**, wherein the second shaft portion reciprocably supports the actuator, the actuator being movable from a first position spaced from the cutting element to a second position in contact with the cutting element.

5. The open electrosurgical forceps according to claim **4**, wherein upon displacement of the actuator from the first position to the second position, the actuator engages the camming surface of the cutting element and urges the cutting element from the first position to the second position.

6. The open electrosurgical forceps according to claim **1**, wherein the biasing member located at the proximal end of the cutting element is a torsion spring.

7. The open electrosurgical forceps according to claim **4**, wherein movement of the actuator pivots the cutting element between the first and second positions.

8. An open electrosurgical forceps for sealing tissue, comprising:

a pair of shaft portions pivotably coupled to one another at a first pivot, each shaft portion including a jaw member at a distal end thereof for grasping tissue therebetween, each jaw member including a sealing surface adapted to conduct electrosurgical energy through tissue grasped therebetween and one of the sealing surfaces includes a slot defined therein;

a cutting mechanism operatively coupled to at least one of the pair of shaft portions, the cutting mechanism comprising:

a cutting element pivotably coupled to at least one of the jaw members and configured to pivot within the slot, the cutting mechanism being selectively moveable about a second pivot from a first position in which the cutting element is retracted within the slot and a second position in which a cutting edge of the cutting element at least partially projects from the slot to cut tissue disposed between the jaw members;

a biasing member operably disposed on the cutting element and within the jaw member, the biasing member configured for biasing the cutting element toward the first position and pivoting the cutting element about the second pivot, the biasing member including a notched portion configured to facilitate pivoting the cutting element between the first and second positions about the second pivot, the notched portion disposed proximal relative to the second pivot and extending to the cutting edge of the cutting element; and

an actuator operatively associated with the cutting element that, upon movement thereof, selectively pivots the cutting element from the first position to the second position,

wherein the cutting element pivots with respect to the actuator.

9. The open electrosurgical forceps according to claim **8**, wherein the actuator is integrally associated with the cutting element.

10. The open electrosurgical forceps according to claim **8**, wherein the actuator is pivotably coupled to the cutting element.

11. The open electrosurgical forceps according to claim **8**, wherein the actuator is spaced a distance from a first shaft portion.

12. The open electrosurgical forceps according to claim **8**, wherein the actuator selectively activates the cutting element when moved relative to a first shaft portion.

13. The open electrosurgical forceps according to claim **8**, wherein the actuator is a drive rod.

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